International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 2876-2879

Received: 14-03-2018
Accepted: 20-04-2018

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Influence of foliar spray of nutrients and plant growth regulators on physiological attributes and yield of finger millet (*Eleusine coracana* (L.) Gaertn.)

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Abstract
The study was carried out to evaluate the effects of foliar application of nutrients and plant growth regulators on physiology and yield of finger millet. Results showed that foliar application of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth significantly increased the physiological attributes *viz.,* leaf area index, crop growth rate, relative growth rate and net assimilation rate when compared to other treatments. The days to 50% flowering and days to maturity was significantly lowest in foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth over other treatments. Among the treatments foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth recorded maximum grain yield (3593 kg ha^{-1}) and straw yield (8735 kg ha^{-1}) compare to other treatments.

Keywords: foliar application, physiological attributes, salicylic acid, yield

Introduction
Finger millet (*Eleusine coracana* (L.) Gaertn) is an important minor millet crop grown in India and has the pride of place in having highest productivity among millets after sorghum and pearl millet (Saravananpandian *et al.,* 2005). It is also known as Ragi, African millet and Bird's foot millet and an important staple food crop in many hilly regions of the country. It is also known as Ragi, African millet and Bird's foot millet and an important staple food crop in many hilly regions of the country. It is grown both for grain and fodder purpose and is cultivated up to an altitude of 3000 meters above MSL. The crop is well adapted to very poor and marginal uplands where other crops cannot be grown successfully (AICSMIP, 2009) [1]. The recent estimates showed that about 50 per cent of global millet grain production is contributed by pearl millet and about 10 per cent by finger millet.

In recent years, plant growth regulators are being employed increasingly to overcome physiological constraints leading to enhanced production in several crops (Malik *et al.,* 1990) [11]. Application of nutrients through foliar spray at appropriate stages of growth is becoming important for their efficient utilization and better performance of the crop (Anandhakrishnaveni *et al.,* 2004) [3]. Plant hormones affect plant growth in multifarious ways affecting a number of physiological or biochemical processes in plants subjected to biotic and abiotic stresses and salicylic acid is one such plant growth regulators, which participate in the regulation of a number of physiological events taking place in the plant (Ashraf *et al.,* 2010) [4]. Keeping this view in mind, the present study was carried out with the foliar spray of nutrients and growth regulators on the physiology of finger millet.

Materials and Methods
Field experiment was conducted during *rabi* 2013-14 in Eastern block, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore to find out the effect of foliar spray of nutrients and plant growth regulators on growth and yield of irrigated finger millet (*Eleusine coracana* (L.) Gaertn). The soil of the experimental field was sandy clay loam in texture, low in available nitrogen (219.3 kg ha^{-1}), medium in available phosphorus (15.2 kg ha^{-1}) and high in available potassium (390.7 kg ha^{-1}) with pH 8.2 and 0.66% organic carbon.

The experiment was conducted on Variety CO 13, comprising of eight treatments *viz.*, T_1 – Maize maxim 0.4% (2 kg ha^{-1}), T_2 – Maize maxim 0.5% (2.5 kg ha^{-1}), T_3 – Maize maxim 0.6% (3 kg ha^{-1}), T_4 – DAP 2% (10 kg ha^{-1}), T_5 – Boric acid 0.3% (1.5 kg ha^{-1}), T_6 – Salicylic acid 40 ppm (20 g ha^{-1}), T_7 – Gibberellic acid 50 ppm (25 g ha^{-1}) and T_8 – Control (no spray) was laid out in Randomized Block Design (RBD) replicated thrice.

The recommended dose of 60: 30: 30 kg N, P_2O_5 and K_2O ha^{-1} was applied in the form of Urea (46% N), Single super phosphate (16% P_2O_5) and Muriate of potash (60 % K_2O). As per the recommendation, basal application of 30: 30: 30 kg N, P_2O_5 and K_2O_5 ha^{-1} was applied uniformly to all plots at the time of transplanting and the remaining dose of 30 kg N ha^{-1} was applied at 45 days after transplanting. Foliar application of nutrients and plant growth regulators was applied twice at pre and post flowering stage of crop growth. Tamil Nadu Agricultural University has developed "Maize Maxim", a nutrient mixture (major, micro nutrients and growth regulators) to boost maize yield. Keeping this in view, the TNAU maize maxim was also included in the present investigation.

Results and Discussion

Leaf area index

The leaf area index is an important factor determining the dry matter production of a crop and subsequently the yield. The leaf area index (LAI) at 60 DAT and at harvest was significantly influenced by the foliar spray of nutrients and plant growth regulators (Table 1). Among the treatments, foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of growth (T_6) registered appreciably higher LAI of 5.72 and 4.57 at 60 DAT and at harvest, respectively compared to other treatments. The lower leaf area index (4.66 and 3.31 at 60 DAT and at harvest, respectively) was recorded under control (T_8). This might be due to more leaf numbers, leaf length, breadth and tillers. This was in conformity with the earlier finding of Sujatha (2001) [17] in greengram. Salicylic acid promoted increased leaf area in crop plants due to increased leaf number and leaf area as reported by Nawalgatte and Panchal (1991) [14] in redgram.

Crop growth rate

Crop growth rate is a function of light interception by the leaf area of crop which was used to determine the crop production. The maximum crop growth rate (14.56 and 10.13 g m^{-2} day^{-1} at 40 - 60 DAT and 60 DAT - harvest, respectively) was recorded with salicylic acid 40 ppm spray (T_6) Table 1. The maximum effect might be due to higher accumulation of photosynthates in various sinks which resulted in higher rate of crop growth rate. The minimum crop growth rate of 9.76 and 4.45 g m^{-2} day^{-1} at 40-60 DAT and 60 DAT-harvest, respectively was recorded under control (T_8). Similar increase in crop growth rate was reported in rice by Kalpana (1997) [8] and Nagasubramaniam *et al*. (2007) [13] in baby corn.

Relative growth rate

The relative growth rate expresses the dry weight increase in a time interval in relation to the initial dry weight. Among the treatments, salicylic acid 40 ppm twice at pre and post flowering stage of crop growth (T_6) was able to increase the value significantly compared to other treatments and the values were 0.0437 and 0.0162 g g^{-1} day^{-1} at 40-60 DAT and at 60 DAT-harvest, respectively (Table 1). The minimum RGR (0.0330 and 0.0093 g g^{-1} day^{-1}) was observed under control (T_8) at 40-60 DAT and 60 DAT-harvest, respectively. This might be due to enhanced leaf production which in turn increased the source capacity. This was earlier reported by Kuttimani (2006) [10] in greengram.

Net Assimilation Rate (NAR)

Net assimilation rate is an indirect measure of photosynthetic efficiency. Among the treatments, salicylic acid 40 ppm twice at pre and post flowering stage of crop growth (T_6) recorded noticeably higher net assimilation rate (0.3183 and 0.1982 mg cm^{-2} day^{-1}at 40-60 DAT and at 60 DAT-harvest, respectively) Table 1. The lowest NAR value was (0.2372 and 0.1127 mg cm^{-2} day^{-1} at 40-60 DAT and 60 DAT-harvest, respectively) recorded with control (T_8). The higher NAR might be due to the accumulation of more dry matter with the enhancement of photosynthetic efficiency, translocation of photoassimilates and also more leaf area index. Similar finding was already reported by Sujatha (2001) [17] in greengram.

Days to 50 per cent flowering

The data on days to 50 per cent flowering indicated significant difference among the treatments (Table 2). The foliar spray of salicylic acid 40 ppm (T_6) recorded less number of days (71) for 50 per cent flowering. Nitrate reductase is the key enzyme related to flowering process. The increased nitrate reductase activity by the application of salicylic acid (Jagadish *et al.*, 1995) [7] and (Kananbala and Nabakumar, 2003) [9] might be the reason for early flowering induction. Reduced Indole-3-acetic Acid Oxidase (IAAO) activity and increased auxin content also contributed to early flowering, which was achieved by salicylic acid treatment. Salicylic acid in sesame reduced the number of flowering days as reported by Uma Devi (1998) and Manikandan and Sathiyabama (2014) [12] in finger millet.

Days to maturity

The data on days to maturity indicated a significant difference among the treatments (Table 2). Early maturity was observed with foliar application of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth (T_6) in 111 days. The increased nitrate reductase activity by the application of salicylic acid (Jagadish *et al.*, 1995) [7] might be the reason for the induction of early maturity.

Grain Yield

Spraying of foliar nutrients and growth regulators had significant influence on grain yield of finger millet (Table 2). The plant sprayed with salicylic acid at 40 ppm (T_6) produced significantly higher grain yield of 3593 kg ha^{-1}. This was followed by foliar application of gibberellic acid at 50 ppm (T_7) and this was on par with TNAU maize maxim at 0.6% (T_3) with grain yield of 3397 and 3319 kg ha^{-1}, respectively. Significantly lower yield of 2709 kg ha^{-1} was observed with control (T_8). This might be due to enhancement of growth attributing characters like LAI, CGR, RGR and NAR. Dawood *et al*. (2012) [6] observed that increase in kernel yield and yield components of sunflower by salicylic acid were due to the effect of physiological and biochemical processes that led to ameliorate in vegetative growth, active assimilation and translocation from source to sink.

Straw Yield

Salicylic acid at 40 ppm (T_6) recorded the higher straw yield of 8735 kg ha^{-1}. The lowest straw yield (7436 kg ha^{-1}) was recorded with control (T_8). The straw yield enhancement due

to the adoption of different treatments might be due to continuous supply of nutrients which in turn increased the plant height, dry matter production and number of tillers m^{-2} resulting in higher straw yield (Table 2). This is also attributed due to the higher nutrient uptake throughout the crop growth period. The results of the present study were in confirmation with the finding of Amin *et al.* (2008) [2] in straw yield of wheat.

Harvest Index

Harvest index is the best measure of source and sink relationship indicating efficient uptake and utilization of nutrients to biological and economic yield. In this investigation, the foliar application of salicylic acid at 40 ppm recorded higher harvest index value and it was on par with gibberellic acid 50 ppm (Table 2). This might be due to the increased mobilization of metabolites to reproductive sinks. The same results endorse the findings of Pramod kumar *et al.* (1999) [15] in soybean and Sujatha (2001) [17] in greengram. Azizi Kh *et al.* (2012) [5] reported that foliar spray of gibberellic acid increased the harvest index in soybean.

Table 1: Effect of foliar spray on the leaf area index (LAI) and Crop growth rate (g m^{-2} day^{-1}), relative growth rate (g g^{-1} day^{-1}) and net assimilation rate (mg cm^{-2} day^{-1}) of finger millet

Treatment	Leaf area index (LAI)		Crop growth rate (g m^{-2} day^{-1})		Relative growth rate (g g^{-1} day^{-1})		Net assimilation rate (mg cm^{-2} day^{-1})	
	60 DAT	Harvest	40 - 60 DAT	60 DAT - Harvest	40 - 60 DAT	60 DAT - Harvest	40 - 60 DAT	60 DAT - Harvest
T_1 - TNAU maize maxim 0.4% (2 kg ha^{-1})	4.92	3.54	10.54	5.99	0.0350	0.0117	0.2491	0.1428
T_2 - TNAU maize maxim 0.5% (2.5 kg ha^{-1})	5.13	4.12	11.79	7.22	0.0378	0.0132	0.2735	0.1569
T_3 - TNAU maize maxim 0.6% (3 kg ha^{-1})	5.37	4.28	12.97	8.25	0.0404	0.0142	0.2926	0.1715
T_4 - DAP 2% (10 kg ha^{-1})	4.98	3.76	11.12	6.28	0.0362	0.0120	0.2614	0.1447
T_5 - Boric acid 0.3% (1.5 kg ha^{-1})	5.09	4.09	11.67	6.63	0.0374	0.0123	0.2721	0.1452
T_6 - Salicylic acid 40 ppm (20 g ha^{-1})	5.72	4.57	14.56	10.13	0.0437	0.0162	0.3183	0.1982
T_7 - Gibberellic acid 50 ppm (25 g ha^{-1})	5.41	4.36	13.13	8.44	0.0408	0.0144	0.2946	0.1735
T_8 - Control (no spray)	4.66	3.31	9.76	4.45	0.0330	0.0093	0.2372	0.1127
CD (P=0.05)	0.23	0.16	0.73	0.91	0.0017	0.0010	0.0108	0.0105

Table 2. Effect of foliar spray on the days to 50 per cent flowering, days to maturity, grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) of finger millet

Treatment	Days to 50 per cent flowering	Days to maturity	Grain yield	Straw yield	Harvest index
T_1-TNAU maize maxim 0.4% (2 kg ha^{-1})	75	117	2945	7760	27.5
T_2- TNAU maize maxim 0.5% (2.5 kg ha^{-1})	74	114	3200	7996	28.6
T_3- TNAU maize maxim 0.6% (3 kg ha^{-1})	73	113	3319	8270	28.6
T_4- DAP 2% (10 kg ha^{-1})	74	116	2977	7826	27.6
T_5- Boric acid 0.3% (1.5 kg ha^{-1})	74	115	3078	7874	28.1
T_6- Salicylic acid 40 ppm (20 g ha^{-1})	71	111	3593	8735	29.1
T_7- Gibberellic acid 50 ppm (25 g ha^{-1})	73	113	3397	8344	28.9
T_8- Control (no spray)	75	117	2709	7436	26.7
SEd	0.4	0.6	87	140	0.2
CD (P=0.05)	1.0	1.0	187	300	0.3

Conclusion

The results of this study showed that foliar application of nutrients and plant growth regulators influenced physiological traits of finger millet. Foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth significantly increased the leaf area index, crop growth rate, relative growth rate, net assimilation rate, grain yield, straw yield when compared to other treatments.

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